

DETAIL DESIGN OF WASTE PLASTIC BOTTLES RESCUE BOAT

LAW XUE NI

Report submitted in partial fulfillment of the requirements
for the award of the degree of
Bachelor of Mechanical Engineering

Faculty of Mechanical Engineering
UNIVERSITI MALAYSIA PAHANG

JULY 2012

ABSTRACT

The increasing numbers of waste plastic bottles over the years has create environment issue across the world. By using the waste plastic bottles to arrange at the waterline section of a boat not only to instill the awareness regarding environment issue, but enhance the safety of the boat. Obviously, a fiberglass boat has the tendency to crack during the hit by the heavy wave or accidents. Hence, the wasted plastic bottles filled inside the rescue boat could act as a floating object to support the rescue boat for a while and avoid the boat to sink directly. Despite of the arrangement of bottles in the boat is major objective in the thesis; the design of general arrangement of the boat behaves as a part of objectives. The design of general arrangement is followed the Safety Of Life At Sea (SOLAS) regulations and several analyses on the design have been made to show the compatible of the design. The methodology utilized in this project from the design software to lines plan and general arrangement of rescue boat. From the result, the total displacement of rescue boat is 868.7kg including six people with an average weight of 100kg. The total wasted plastic bottles used are 332 with a total weight of 13.12kg. If the leaking problem occurs, the bottles are able to support 56% of buoyancy from the total weight. The design of the general arrangement is also consider the weigh distribution of a boat. The passenger seat is concentrated at the middle of the boat to maintain the stability of the rescue boat.

ABSTRAK

Jumlah botol plastik sampah yang meningkat setiap tahun telah mewujudkan isu alam sekitar di seluruh dunia. Dengan menggunakan botol plastik terbuang untuk menguruskannya di bawah bahagian air bot bukan sahaja untuk memupuk kesedaran mengenai isu alam sekitar, tetapi meningkatkan keselamatan bot penyelamat. Selain itu, bot yang dibuat daripada gentian serabut kaca mempunyai kecenderungan untuk pecah apabila dipukul ombak atau terlibat dalam kemalangan. Oleh itu, botol plastik terbuang yang diisi dalam bot boleh bertindak sebagai object terapung untuk menyokong bot penyelamat untuk mengelakkan bot tenggelam serta merta. Walaupun susunan botol dalam bot antara objektif projek ini, reka bentuk susunan umum bot juga sebahagian daripada objektif. Reka bentuk susunan umum mengikuti peraturan Keselamatan Kehidupan Pada Laut (SOLAS) dan analisis bot telah dibuat untuk menunjukkan serasi reka bentuk. Kaedah yang digunakan di dalam tesis ini dari perisian reka bentuk, pelan garis sehingga susunan umum bot. Daripada keputusan kajian ini, anjakan jumlah bot penyelamat adalah 868.7kg termasuk enam orang yang mempunyai berat sebanyak 100kg. Jumlah botol plastik terbuang yang digunakan adalah 332 buah dan beratnya adalah 13.12kg. Jika berlakunya bot membocor, botol terbuang akan menyokong 56% daripada berat keseluruhan. Reka bentuk susunan umum juga tidak melupakan analisis pengagihan berat bot. Tepat duduk penumpang tertumpu pada bahagian tengah bot untuk mengekalkan kestabilan bot penyelamat.

TABLE OF CONTENTS

EXAMINER'S APPROVAL DOCUMENT	Page i
SUPERVISOR'S DECLARATION	ii
STUDENT'S DECLARATION	iii
DEDICATION	iv
ACKNOWLEDGEMENTS	v
ABSTRACT	vi
ABSTRAK	vii
TABLE OF CONTENTS	viii
LIST OF TABLES	xii
LIST OF FIGURES	xiii
LIST OF ABBREVIATIONS	xv
LIST OF APPENDICES	xvi
CHAPTER 1 INTRODUCTION	1
1.1 Background	1
1.2 Problem Statement	2
1.3 Objective	3
1.4 Project Scope	3
1.5 Expected Outcome	3
1.6 Significant of The Study	3
1.7 Process Flow Chart	4
CHAPTER 2 LITERATURE REVIEW	5
2.1 Archimedes Principle	5
2.2 Ship Designed Using Wasted Plastic Bottle	6
2.2.1 Plastic Bottle	6
2.2.2 Plastiki	7

2.2.3	Isara Bottle Boat	8
2.2.4	Bottle Up	9
2.3	General Features of Rescue Boat	10
2.4	Buoyancy and Stability of Ship	12
2.4.1	Ship Buoyancy	12
2.4.2	Ship Stability	13
2.5	Principle Dimension of Hull	18
2.5.1	Length Over All	18
2.5.2	Length Between Perpendiculars	18
2.5.3	Waterline Length	19
2.5.4	Beam	20
2.5.5	Draft	20
2.6	Coefficient Used in Hull Construction	21
2.6.1	Block Coefficient	21
2.6.2	Prismatic Coefficient	22
2.6.3	Mid Coefficient	23
2.6.4	Waterplane Coefficient	24
2.7	Lines Plan	24
CHAPTER 3	METHODOLOGY	26
3.1	Project Process Flow	26
3.2	Parameter Identification	29
3.3	Design The Shape of Boat Using DELFTSHIP	29
3.4	Coefficient Calculation	29
3.3.1	Block Coefficient	29
3.3.2	Midship Coefficient	30
3.3.3	Prismatic Coefficient	30
3.3.4	Waterplane Coefficient	30
3.5	Determination of Rescue Boat Resistances and Engine Estimation	31
3.5.1	Frictional Resistance	31
3.5.2	Residual Resistance	31
3.5.3	Total Resistance	31

3.5.4	Effective Horse Power	31
3.5.5	Major Driving Force	32
3.6	Determination of The Displacement of Boat	32
3.6.1	Deadweight tonnage	32
3.6.1.1	Weight of Bottles	32
3.6.1.2	Weight of Fresh Water	33
3.6.1.3	Weight of Food	33
3.6.1.4	Weight of Passengers	33
3.6.1.5	Other Weight	33
3.6.1.6	Total Deadweight Tonnage	33
3.6.2	Lightweight Tonnage	34
3.6.2.1	Weight of hull	34
3.6.2.2	Weight of General Arrangement	34
3.6.2.3	Weight of machine	34
3.6.2.4	Other Weight	35
3.6.2.5	Total Lightweight Tonnage	35
3.7	Preliminary Assessment of The Stability of The Boat	35
3.7.1	Calculation of Height of The Center of Buoyancy From Keel	35
3.7.2	Calculation for Metacentric Radius	36
3.7.3	Calculation for Vertical Distance From Keel to the Metacenter	36
3.7.4	Calculation for Vertical Distance From Keel To The Center of Gravity	36
3.7.5	Calculation for Height of Metacenter	36
3.8	Curve Sectional Area	37
3.8.1	Midship Area	37
3.8.2	Longitudinal Centre of Buoancy	37
3.8.3	Prismatic Curve Percentage	37
3.8.3.1	Foremost Prismatic Coefficient	37
3.8.3.2	Aftermost Prismatic Coefficient	38
3.8.4	Determination on Area of Each Section of Boat	38
3.9	Waste Plastic Bottles Properties	39
3.10	Design of The Boat In SOLIDWORKS	40

3.11	Analysis	40
CHAPTER 4	RESULT AND ANALYSIS	41
4.1	Design of The Rescue Boat Body	41
4.1.1	Design Dimension of The Rescue Boat	41
4.1.2	Lines Plan Design of Rescue Boat	41
4.2	Hydrostatic Analysis	44
4.2.1	Volume Properties	44
4.2.2	Sectional Area Properties	45
4.2.3	Waterplane Properties	46
4.2.4	Coefficient Calculation	46
4.2.5	Resistance Analysis and Engine Power Estimation	46
4.2.6	Displacement Estimation	48
4.2.7	Stability Analysis of Rescue Boat	50
4.3	Arrangement of Bottles In Rescue Boat	51
4.3.1	Waste Plastic Bottles Properties	51
4.3.2	Designed Rescue Boat with The Arrangement of Bottles	53
4.3.3	Analysis of Design	54
4.4	General Arrangement	56
4.4.1	Detail Design of The General Arrangement	56
4.4.2	Analysis of General Arrangement	58
CHAPTER 5	CONCLUSION AND RECOMMENDATION	59
5.1	Conclusion	59
5.2	Recommendation	60
REFERENCES		61
APPENDIX		63

LIST OF TABLES

Table No.	Title	Page
4.1	Dimension of hull for Rescue Boat	41
4.2	Volume Properties of Rescue Boat	44
4.3	Waterplane Properties of Rescue Boat	46
4.4	List of Coefficient of Rescue Boat	46
4.5	Total Resistance at different Speed of Boat	47
4.6	Engine Power Estimation At Speed of 20knot	48
4.7	List of Outboard Motor In The Market	48
4.8	Deadweigh (DWT) of A Rescue Boat	49
4.9	Lightweight (LWT) of A Rescue Boat	49
4.10	Metacenter Height At Different Draft	50
4.11	Mass and volume for selected bottle	52
4.12	Mass Analysis of Waste Plastic Bottles	55

LIST OF FIGURES

Figure No.	Title	Page
1.1	The Sales, wasting and recycled rate of PET bottle in US from 1991 to 2009.	1
1.2	Process flow chart	4
2.1	Archemedes of Syracuse (287-212 BC)	6
2.2	The voyage of Plastiki in sea	8
2.3	Drawing of the Isara Bottle boat	9
2.4	The Fiji's bottle boat named Bottles Up	10
2.5	The Interior Design of a Rescue-B	11
2.6	Top, side and front view of a typical rescue boat	11
2.7	Example of displacement data	12
2.8	Displacement curve for cruiser	13
2.9	Development of righting moment when a stable ship inclines	14
2.10	Development of an upsetting moment when an unstable ship inclines	14
2.11	Curve of static stability	15
2.12	A. Stable condition, G is below M; B. Unstable condition, G is above M	17
2.13	The Length Overall of Titanic	18
2.14	The Length Between Perpendiculars (LBP/LPP) of Titanic	19
2.15	LOA and LWL of a kayak	19
2.16	The centerline and the beam of a boat	20
2.17	Beam, freeboard, draft, keel and a propeller of a vessel	21
2.18	Block coefficient	22
2.19	Longitudinal prismatic coefficient	23
2.20	Midship coefficient	23
2.21	Waterplane coefficient	24
2.22	The example of lines plan for a cargo ship	25
3.1	Project process flow chart	26
3.2	Waste plastic bottles	39

4.1	Lines plan of rescue boat	42
4.2	Sheer plan view of rescue boat	42
4.3	Body plan view of rescue boat	43
4.4	Breadth plan view of rescue boat	43
4.5	Othorgraphic view of rescue boat	44
4.6	Sectional area curve	45
4.7	Graph total resistance versus speed of boat	47
4.8	Graph metacenter versus draft	50
4.9	The 3D view from Solidworks 2011	51
4.10	Dimensions of waste plastic bottle	52
4.11	Body plan of rescue boat with waste plastic bottles arrangement	53
4.12	Sheer plan of rescue boat	53
4.13	Breadth plan of rescue boat	54
4.14	Plastic bottles arrange in each station of the boat	54
4.15	General arrangement of rescue boat	56
4.16	Side view of the designed rescue boat	57

LIST OF ABBREVIATIONS

PET	- Polyethylene Terephthalate
BC	- Before Christ
SOLAS	- Safety of Life At Sea
LOA	- Length Over All
LBP	- Length Between Perpendiculars
LWL	- Waterline Length
B	- Beam/Breadth
D	- Draft/ Draught
DWT	- Deadweight Tonnage
LWT	- Lightweight Tonnage
EHP	- Effective Horsepower
BHP	- Major Driving Force
CSA	- Curve Sectional Area
LCB	- Longitudinal Centre of Buoyancy
NSP	- Nederlandsch Scheepbouwkundig Proefstation
HP	- Horsepower
LSA	- Life Saving Appliances

LIST OF APPENDICES

Appendix	Title	Page
A	SOLAS Standard of A Rescue Boat Fitting And Inventory	63
B	Engine Specification	64
C	Hydrostatics Report	65

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

The waste plastic bottle has a trend of increasing over the year. This can be shown at the graft below. The Figure 1.1 shows the sales wasted and recycled bottle rate in the United State from year 1991 to 2009. Both the sales and wasted bottle have increase from the year 1991 and reached the peak in year 2007. The sales and wasted bottle then experience the shrinkage after the year until 2009. Luckily, the recycle bottled show an increasing rate through out the year. However, the recycled rate is far less behind the wasted rate.

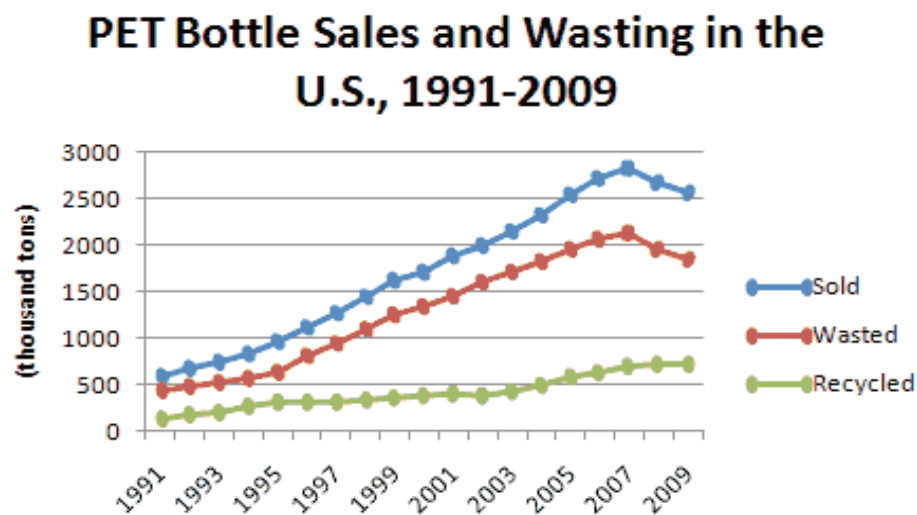


Figure 1.1: The wasted and recycled rate of PET bottle in US from 1991 to 2009

Source: <http://www.container-recycling.org/facts/plastic/data/petsaleswasterec.htm>

The wasted plastic bottles inspire the idea of making rescue boat using the wasted plastic bottle. This idea is not only to inculcate the environmental awareness among the public, but it can increase the safety of the rescue boat.

The project is continuing from the previous study of design rescue boat by using waste bottle plastic. The plastic bottles will be arrange in the core of the boat to avoid sinking since the fiberglass layer of the boat have the tendency to crack.

Detail design of ship is very important before it is ready to fabricate. Besides, material analysis, technical aspect of the ship operation and facility of ship will consider on the design. The project would determine the amount needed of the wasted plastic bottles in the core of the boat. The line plan and the general arrangement of bottles in the boat will be designed and some theoretical analysis will be done. On the other hand, the facilities of the rescue boat will of the rescue boat will be determined through this project.

1.2 PROBLEM STATEMENT

The boat that made from the fiberglass is noticed to have high possibility to crack at the bottom part of the boat. It may due to the hit by the heavy wave. Besides, the fiberglass will have the tendency to crack during an accident. The consequence is the boat will sink and fail to act as a rescue boat. To overcome this problem, there is an idea to design a fiberglass boat that has arrangement of waste plastic bottles in the frame of rescue boat before it laminated by fiberglass so that even the fiberglass layer crack the boat will still float.

On the other hand, 40 millions of waste plastic bottle are throwing away a day. In contrast, the recycling rate for plastic soft drink bottles is around 30 percent. The community nowadays still lack of conscious about the consequences of producing waste plastic. Furthermore, the concept of reuse the plastic bottle still far away in the peoples' mind. Hence, the use of waste plastic bottle inside the rescue boat would give the plastic bottle a second chance and this action is able to instill the conscious in reduce the use of plastic bottle among the university students.

1.3 OBJECTIVE

The main objective of this study is to design a fiberglass rescue boat that has arrangement of waste plastic bottles in the frame of the rescue boat.

1.4 PROJECT SCOPE

The scopes of this project are:

- i. Detail material used and the orientation of the waste plastic bottle in the boat.
- ii. Design of the ship facility.
- iii. Technical analysis of ship operation.

1.5 EXPECTED OUTCOME

The expected outcome of the project is to produce a line plan design of the rescue boat together with the arrangement of the plastic bottles. The line plan design consists of the waterline and baseline in each ordinate and also the orientation of bottle arrangements and amount of bottles needed.

1.6 SIGNIFICANT OF THE STUDY

The greatest advantage of the plastic bottles rescue boat is to provide extra safety purpose for both the rescue boat itself and passengers. The boat is not facing the sinkage problem if cracking occurred at the bottom part of the fiberglass.

1.7 PROCESS FLOW CHART

Figure 1.2 shows the process flow of how this project is done. This makes useful tools how processes work is done throughout the project.

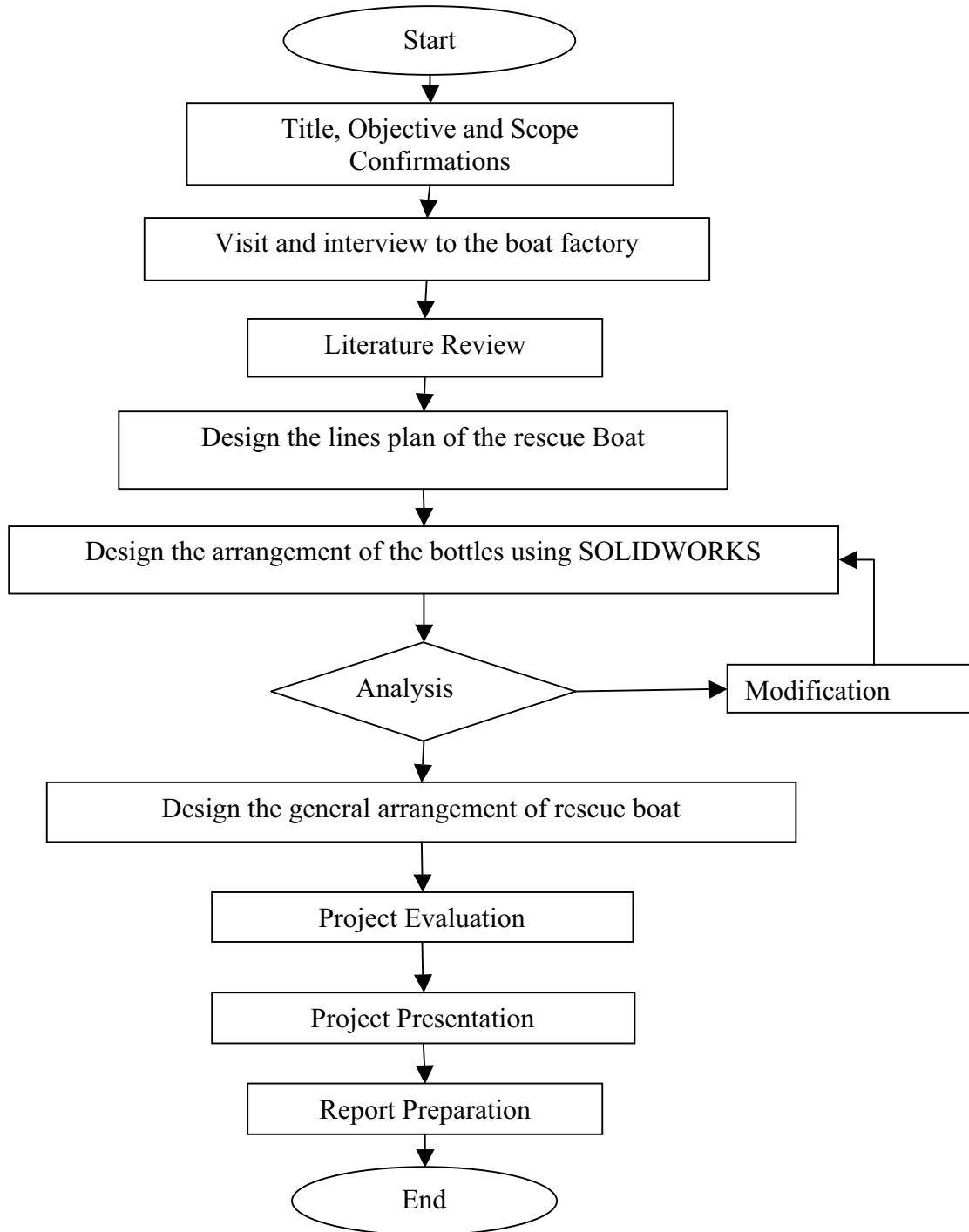


Figure 1.2: Process flow chart

CHAPTER 2

LITERATURE REVIEWS

2.1 ARCHIMEDES'S PRINCIPLE

The Archimedes principle is one of the earliest scientific principles and it is used in a wide range of application. A mathematician, Archimedes of Syracuse, discovered the theory of buoyancy. The idea came from Archimedes who had a flash of inspiration as he felt his own buoyancy in a public bath.

“ The buoyant force acting on a body immersed in a fluid is equal to the weight of the fluid displaced by the body, and it acts upwards through the centroid of the displaced volume. ”

Archimedes principle stated that buoyant force acting on an immersed object is equal to the weight of the displaced water. The explanation is not limited to the liquid but the gases too. Both density of an object and fluid will determine the buoyant force. An object will float if the object is less dense than the fluid. In contrast, an object will sink if the object is denser than the fluid.



Figure 2.1 : Archimedes of Syracuse (287-212 BC). Greek mathematician, physicist and engineer. Discovered the formulae for area and volume of cylinders and spheres, and invented rudimentary infinitesimal calculus. Formulated the Law of the Lever, and wrote two volumes on hydrostatics titled *On Floating Bodies*, containing his Law of Buoyancy

Source : Benny Lautrup, 2008

2.2 SHIP DESIGNED USING WASTED PLASTIC BOTTLE

2.2.1 Plastic Bottle

The bottles for mineral water are utilized by Polyethylene Terephthalate (PET) plastic, an amorphous or transparent material. A PET plastic is also included the semi-crystalline thermoplastic material that owns the opaque and white surface. The latter is widely used to store the detergent, lubricant and etcetera. This material is generally good resistance to mineral oils, solvents and acids but not to bases. The semi-crystalline PET has better strength, ductility, stiffness and hardness compared to amorphous type that has better ductility with less stiffness and hardness. On the other hand, the PET will not react with oxygen and carbon dioxide and this well barrier is suitable for the use for mineral water.

2.2.2 Plastiki

Plastiki is a ship that inspired by the Kon-Tiki voyage, which made from approximate 12,500 reclaimed plastic soda bottles (PET). The owner or the expedition leader David de Rothschild conceived the idea after reading a report that indicated the world's oceans were under the threaten of the pollution. The voyage set sail from San Francisco; United State to Sydney Australia across the Pacific Ocean and the duration for the voyage took about 4 months.

Then, his team started to design by fit the bottles together in the right way was the key to producing a solid structure and this inspiration was largely taken from the formation of a pomegranate which pack together many soft seeds to create a hard outer structure. The bottles provide the boat 68% of her buoyancy.

The main material- plastic bottles were filled with dry ice, making them solid and consist in order to provide a smooth exterior as streamline as possible. Despite of recycling the use of plastic bottles, the Plastiki's structure would be made by a new material called Seretex, which is a self re-enforcing PET that is fully recyclable.

Besides, the team has developed special organic glue using cashew nut husks and sugarcane in order to apply at places within the structure. This organic glue is friendly environmental and it is non-toxic material that will not pollute the seawater. Despite all this plastic, the Plastiki weighs in at 12 tons. This ship is 60 feet long and 40 feet high.

On the other hand, the vessel consist a cabin that provide a living space for the crews. The cabin consist a sleeping quarter, main cabin with two sleeping berth, galley, slself-contained head and navigation room. The cabin is inspired from the eggshell and it is capable to withstand outside pressure though it is thin. The roof of cabin covered by solar panel to generate electricity and has a rainwater capture system to collect the fresh water. Other than solar panel, the electricity bike and wind turbine act as a mini power station to generate adequate electricity for navigation and communication system.

The six-crew members meet and share at least one meal per day and the meal was prepared using the galley. Since there is no fridge on board and the team have to be innovative in their preservation methods such as sourcing local, sustainable produce to be canned, dried and stored pre-departure. However, the vessel contained vertical hydroponic gardens to provide the crew with nutritious greens throughout the voyage.



Figure 2.2: The voyage of Plastiki in sea

Source: <http://www.theplastiki.com/photos/>

2.2.3 Isara Bottle Boat

An Isara charity project based in Nong Khai, and the boat founder Kirk Gillock design the catamaran. He plan to travel down the Mekong River by boat to remind the people about the household waste that pollute the river. The main design is strongly refer to the Plastiki. The two hulls are made from timber, steel frame join the hulls and support the cabin structure. The buoyancy obtained solely from 5000 recycled plastic bottles. The boat powered by electric motors with a combination of wind and solar power generation.

Before fabrication, the sample pontoon of about 100 bottles is ready to undergo an experiment. These bottles are arranged in different layouts to see which would be the

most efficient and practical. These three layouts include cylindrical, trapezoid, and rectangle shape. The cylindrical was the easiest to make but connecting the rest of the boat to it would have been very difficult. A trapezoid shape was tested and the result in less drag. A rectangle arrangement will hold more buoyancy and create more buoyancy, but it has more drag.

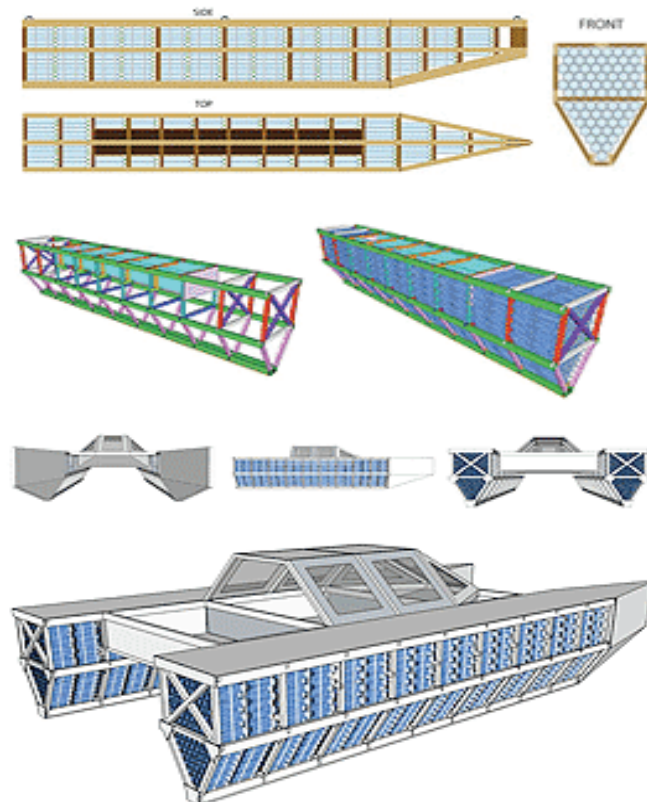


Figure 2.3: Drawing of the Isara Bottle boat

Source: <http://www.isara.org/community/pages/plastic-bottle-boat>

2.2.4 Bottle Up

The owner's Tom Davies, who claimed that "Bottles Up" is the first plastic bottle in Fiji. 600 empty beverage bottles were used to construct the Fiji's first recycled bottle boat with the length of 4.5 meters and wide of 1.4 meter. All the plastic bottles are 600 ml plastic bottles and the small boat was said to have the ability to cater three big Fiji man. These bottles glue together with a layer of foam underneath to aid in

floatation and some plastic sheeting for the seats and floor deck. Davies said that this is a better way to recycle the bottles as it was tested it can float pretty well. Hence, “Bottles Up” will be used as a form of activity for tourist to paddle around an 110ft-deep lake near his chalet.



Figure 2.4: The Fiji’s bottle boat named Bottles Up

Source: The Fiji Time Online, 2010

2.3 GENERAL FEATURES OF RESCUE BOAT

A rescue boat is a vessel that provide special feature for rescuing or saving the lives of people at the sea. Rescue boat may be either of rigid or inflatable construction or a combination of both and it shall not less than 3.8m and not more than 8.5m in length. Besides, the rescue boat shall be capable of carrying at least five seated persons and a person lying on a stretcher. A rescue boats shall have sufficient mobility in a seaway to enable persons to be retrieved from water. On the other hand, a rescue boat shall be fitted with an inboard or outboard engine. If it is fitted with an outboard engine, a rudder and tiller may form part of the engine. The rescue boat is also need the capable to tow life rafts. Figure 2.5 shows the interior design of a rescue boat. The enclosed

cabin area is designed to accommodate a stretcher and a rescue team of three. The storage of rescue materials is located under the patient stretcher area and consist a navigation area. The absorbing seats are designed to absorb any vibration to increase the comfort of the passenger. All the design of rescue boat must follow the SOLAS regulation. Please refer Appendix A.

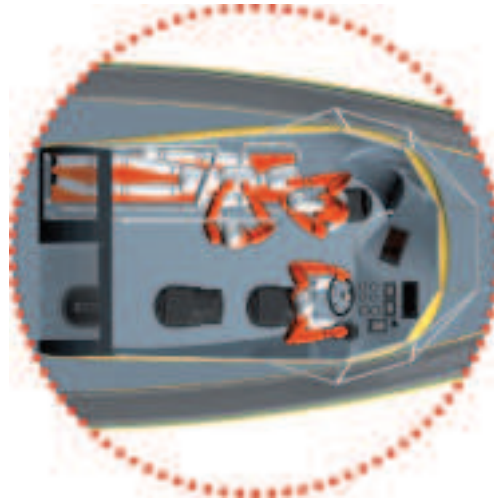


Figure 2.5: The Interior Design of a Rescue-B

Source: <http://www.rescueboat.eu/the-boat/>

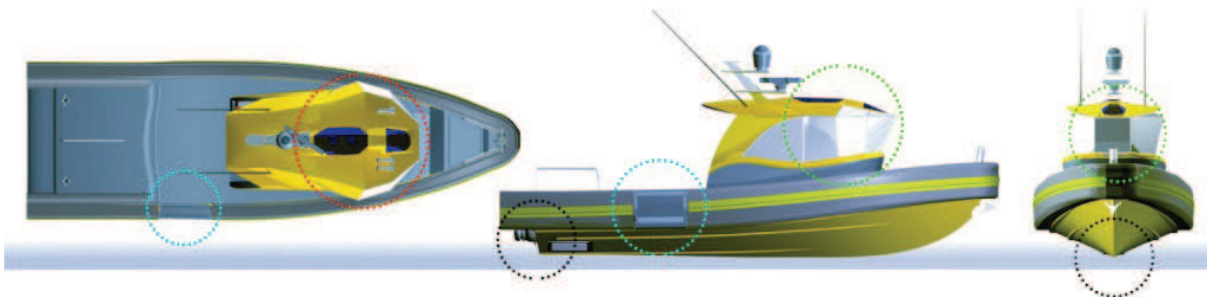


Figure 2.6: Top, side and front view of a typical rescue boat

Source: <http://www.rescueboat.eu/the-boat/>

2.4 BOUYANCY AND STABILITY OF SHIP

2.4.1 Ship Buoyancy

Ship buoyancy may define as the float ability of a vessel. If the weight of the vessel is less than the weight of an equal volume of water, the vessel will rise or float. The rises of the vessel is due to the force that buoys it up is greater than the weight of the vessel. It will continue to rise until it is partly above the surface of the water. Furthermore, the volume of the submerged part of a floating ship provides the buoyancy to keep the ship float. When the ship is in rest mode, the buoyancy must be equal to the weight of the ship. Hence, the weight of the ship called as displacement, meaning the weight of the volume of water displaced by the hull.

Draft is the depth of a ship below the waterline. As the displacement increase, the draft increases. Figure 2.7 shows the successive draft lines on the midship section of a ship. The volume of an underwater body for a given draft line can be measured in the drafting room by using graphic or mathematical means. The values obtained are plotted on a grid on which y-axis represent the draft in feet and x-axis represent the displacement in thousand tons. Figure 2.8 show a smooth line is faired through the points plotted and providing a displacement curve.

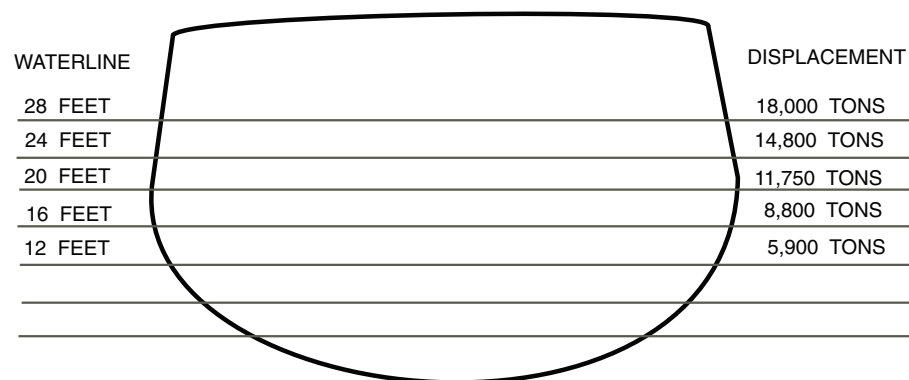


Figure 2.7 : Example of displacement data

Source: Introduction to Naval Engineering, David A. Blank, 2005